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# Energy infrastructure and the fate of the nation: Introduction to special issue

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ABSTRACT

In this article we introduce a Special Issue of *Energy Research and Social Science* focused on energy infrastructure and the political economy of national development. Many countries are experiencing transformational growth in energy infrastructure, such as transmission and distribution systems; import, export and storage facilities; the development of domestic energy resources; and construction of new power generating stations based on wind, water, coal, gas and nuclear sources. Large-scale projects like these are frequently justified by appeals to grand narratives – promoting economic growth, securing energy supply, modernizing energy service provision, and transitioning to more environmentally sustainable energy systems - in which the fate of the nation is closely tied to infrastructural development. The papers in this collection present compelling empirical evidence of how claims for energy infrastructure's national significance and/or necessity intersect with the (re)production of political and economic power. Drawing on case material from Africa, the Americas, Asia, Australia and Europe, they highlight the capacity of different energy technologies and infrastructural assemblages to shape political and economic outcomes beyond their role in storing, transporting or transforming energy. This Introduction to the Special Issue does three things. First, it characterises the scale and significance of the contemporary 'infrastructural moment', observing how, in many national contexts, energy policy-making remains centralised and divorced from public participation. Second, it critically differentiates existing literature on the political economy of energy infrastructure to identify five distinctive ways in which research understands the 'political work' infrastructure performs. Third, it introduces the papers in the Special Issue and organises them into four key themes. Overall, the Introduction affirms the importance for social science of understanding the economically and politically constitutive power of energy infrastructures. The critical reflexivity this requires is essential to moving towards energy infrastructures that are just, equitable and sustainable.

## 1. Introduction

Securing reliable, affordable and environmentally sustainable energy supplies is one of the grand challenges of the 21st century. Energy infrastructure sits at the middle of this challenge, a point of convergence for a wide range of policy objectives from economic growth and national security to mitigating climate change and social inequality.[1] The scale of the energy infrastructure challenge is very large indeed. The International Energy Agency estimates $44 trillion is required in new energy supply infrastructure in the period to 2040 [1], while an annual expenditure of $45 billion is required to address UN Sustainable Development Goal 7 and deliver affordable, sustainable and reliable access to modern energy services.[2] Developing new and upgraded electricity and gas transmission systems in Europe is expected to cost around €210 billion before 2022 [2]; and in the US, the 'infrastructure investment gap' for electricity generation, transmission and distribution is estimated to be $177 billion between 2016 and 2025 [3]. Calls for new or expanded energy infrastructure are now common across many different areas of socio-economic, political and environmental policy, from promoting economic growth and ensuring national security, to modernizing housing and transport services and transitioning to more sustainable forms of living. In short, investing in energy infrastructure offers an apparent 'solution' to a range of contemporary challenges.

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[1] The EU's 2011 Infrastructure Package, for example, targeted support for new energy infrastructure to meet multiple objectives around energy security, energy market liberalization and decarbonization. With the Lisbon Treaty (2009), energy infrastructures became a shared competence between member states and the European Commission.

[2] Data from IEA (2014) and the SE4All Finance Committee Report (2015); as cited in World Bank, see http://www.worldbank.org/en/topic/energy/brief/sustainable-development-goal-on-energy-sdg7-and-the-world-bank-group

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Our starting points for this Special Issue[3] are two-fold. First is a recognition that many countries are experiencing transformational growth in energy infrastructure. This growth has materialized in a variety of forms, from high-profile megaprojects such as large power generation facilities, oil and gas pipelines, electricity transmission systems, and major resource extraction projects; to a vast array of smaller-scale infrastructures that are replicated across multiple urban and regional contexts, including gas and electricity distribution systems, energy storage facilities, off-grid power generation, and a variety of 'smart' infrastructures that create new dynamics of energy management. While the build-up of these and other energy infrastructure is not itself a novel phenomenon, there are reasons (as we outline below) to consider the current period of transformational growth historically distinctive and to take seriously what we are calling the contemporary 'infrastructural moment.' Our second starting point is the observation that promotion and development of energy infrastructure is frequently justified by reference to 'grand narratives' that imply some form of universal benefit and/or urgent necessity. These invoke ostensibly common objectives and shared scales, such as the importance of addressing global climate change, securing urban competitiveness, or driving national development and, in this way, forge a connection between specific material investments and broader improvement of social conditions. In this Special Issue we are interested in the articulation of energy infrastructure with projects of improvement (economic growth, modernization, decarbonization, enhancing security) at the national scale, and how claims about the importance, necessity or urgency of energy infrastructure often position it as a vital national project on which the 'fate of the nation' depends.

A primary objective in bringing together this Special Issue, then, is to critically examine what happens politically and economically when questions of energy infrastructure intersect with nationally-scaled projects of development. We suggest the current conjuncture is marked by a ramping up of energy infrastructure investment in ways that make it possible to speak of an 'infrastructural moment'. This is characterized, in part, by the scale of current investments and the prospective possibilities of future energy infrastructure: here the 'financing gap' alluded to in the first paragraph is key, as it positions energy infrastructure as an investible proposition and an asset class from which future returns may be derived [4,83]. The infrastructural moment is also characterized by the way energy infrastructures draw together and advance the material interests of specific actors and groups across multiple scales, including international capital. It is in this multi-actor and multi-scalar context, then, that a resurrection or 'return' of the national imaginary/national scale concerning debates on and policy approaches to energy has to be understood. The circumstances surrounding this reassertion of the national in policy debates are complex and stem from several different trajectories. In some contexts, for example, it reflects a post-neoliberal turn and the reassertion of the national state as an economic actor (i.e. resource nationalism in Venezuela, Bolivia and Ecuador), although in circumstances where the capacity of the national state to act depends on its ability to articulate domestic resource rents with international credit and debit (such as the role of Chinese infrastructural loans in financing hydroelectric power development in Ecuador, see Purcell and Martinez-Esguerra [82]). In other contexts, it signals the rise of a populist and authoritarian form of economic nationalism (i.e. Turkey, Poland, India, the USA), where energy projects are harnessed to claims for national security and development in ways that occlude the particular interests of private capital and suppress dissent (see, for example, Arifi and Späth [96]; Finley-Brook et al. [102]). In countries that embraced economic liberalization in the energy sector and the growth of energy investment and trade (such as the UK), claims for the national importance of new energy infrastructure reflect concerns about growing import dependency and the way energy systems are no longer 'nationally' contained but shaped by decisions at multiple scales. In such contexts, the scaling of energy infrastructure as a national policy concern also reflects the limited capacity of national governments in liberalised and globalised energy markets to directly deliver a response to public concerns around energy security, climate change and the affordability of energy. Elsewhere, the assertion of the nation around energy infrastructures is an artefact of international agreements (i.e. SDGs, the Paris Agreement) signed and ratified by nation-states—which lend legitimacy to the national scale via compliance.

It is important that social science research on energy better understand these complex intersections between energy infrastructure and the political economies of national development, we suggest, for at least three reasons. First, claims about the national significance of infrastructure 'do political work' by, for example, licensing state intervention in energy systems, establishing political authority, and marginalizing criticism. Several of the papers in this collection present compelling evidence for how claims for energy infrastructure's national significance and/or necessity intersect with the (re)production of political power, and how appeals to common interests are used to secure particular interests and prioritize some interests and scales over others. This line of enquiry is important because, in many countries, energy policy-making remains centralized and divorced from public participation. Questions about who bears the costs of power stations, pipelines and other energy infrastructures deemed 'critical' to national security or development now animate calls for more inclusive and sustainable energy systems. Opposition to such infrastructure is increasingly framed in terms of democratic participation, citizenship and social justice, with each of these terms making alternative claims on the national state in regard to the decision-making procedures and socio-environmental consequences of infrastructural development. Some of the papers in this Special Issue explore such questions about the socially-constitutive power of energy systems empirically, highlighting the capacity of different energy technologies and infrastructural assemblages to reproduce social power and shape political and economic outcomes ([5,6,67]).

A second reason for social science research on energy to take seriously the intersections of energy infrastructures with national development concerns the role of energy infrastructure in enabling and sustaining particular forms of political economy. This includes, for example, the importance of electricity transmission systems, gas pipelines and storage facilities to constituting wholesale energy markets and enabling the adoption of economic liberalization policies in national energy sectors. Chile's introduction of wholesale markets for electricity in 1978, and comprehensive electricity and gas sector privatization in the UK beginning in the 1980s illustrate how infrastructures for circulating gas and electricity have been a key experimental site for economic deregulation and the introduction of market principles, commercial logics and private capital into national economies (for the case of Turkey in relation to hydroelectric infrastructures, see Eren [86]; Erensü [99]). Other examples include the significance of energy infrastructure (and infrastructure in general as an asset class) to processes of financialization and the evolution of the macro-economy; the influence of infrastructural form on the scope for collective mobilization and the capacity of labor, through its control of key investments that shape the distribution of social power and the evolution of the welfare state (Mitchell [67]; see also Prinz and Pegels [84] on the labour movement's influence on Germany's energy transition; and the influence of infrastructural scale, complexity and capital costs on the centralization of

[3] The origins of this Special Issue (although not its final form) lie in an interdisciplinary workshop the authors convened in Istanbul in June 2016 with the support of a British Council Katip Çelebi-Newton Fund Researcher Links Workshop Grant. The workshop brought together around 30 UK and Turkey-based social science researchers for five days at Boğaziçi University in Istanbul, to explore the social processes underway around energy infrastructure. It included participation by local community organizations, public institutions, environmental NGOs and energy professionals from the public and private sectors. Following the Istanbul workshop, the authors worked with the Editors of ERSS to issue a global call for papers on the Special Issue theme.

control, authority and expertise). In short, infrastructures for energy have been a key frontier in the evolution of economic organizational forms—around markets, finance, labor organization and techno-scientific expertise—that transcend the energy sector, such that they can be considered integral to the reproduction of economic power.

Third (and building on the above), careful analysis of so-called 'national' energy projects is necessary because appeals to the scale of the nation occlude the multi-scalar political economies that sustain, and flow from, energy infrastructure investment. 'National' energy infrastructure is frequently an assemblage of cross-border flows of finance, labor and materials, in ways that complicate simplistic appeals to national development or the national interest. The provocation motivating this Special Issue, then, is that there is analytical value in bringing conceptual arguments about the politically- and economically-constitutive power of energy infrastructure into conversation with a diverse range of empirical contexts in which energy projects of national importance are being imagined, planned, implemented and resisted. The papers in this Special Issue examine infrastructures associated with conventional energy resources, low-carbon energy systems and cross-border energy projects. From hydropower development and smart electricity grids, to coal mine expansion and oil and gas pipeline projects, the papers show how energy infrastructures are positioned by national policy makers and other actors as promoting economic growth, securing energy supply, modernizing energy service provision, and transitioning to more environmentally sustainable energy systems. However, the papers we have assembled do more than simply confirm a contemporary 'infrastructural moment' with regards to energy and highlight some of its diverse modalities. Applying conceptual approaches from different social science traditions (human geography, international relations, anthropology, political ecology, historical sociology, socio-technical studies), they explore how energy infrastructures do political and economic work—that is, how the significance of these structures transcends their role in storing, transporting or transforming energy in a 'climate-challenged' world [7]. Instead, the social importance of energy infrastructure lies in the political and economic effects to which it can give rise. As a collection, papers in this Special Issue expand the range of cases through which the nexus of energy infrastructure and political and economic power has been examined. Understanding the economically and politically constitutive power of energy infrastructures is important: the critical reflexivity it requires is essential to moving towards infrastructures that are sustainable and socially-just.

## 2. Locating the politics of energy infrastructure: a brief review

Energy infrastructures are examples of what Hughes [8,9] refers to as large-scale technical systems which organise social life. They are the "central nervous systems" of economies ([10] p.7), connect multiple spaces and institutions of energy capture, conversion, transmission, storage, consumption and waste, and play key roles in constituting the body politic [11]. It is not difficult, therefore, to consider that pipelines, electricity transmission and distribution systems, generating stations and other energy facilities have a politics, or create political effects. Indeed, there is now widespread recognition in the social science literature that the significance of energy infrastructure exceeds its technical capacity for moving, converting or storing energy [11,12]. The capacity of infrastructures to organise social relations in significant ways is acknowledged by reference to its systemic and foundational character: Star ([13] p.380), for example, refers to infrastructure as a "system of substrates" while Larkin ([14] p.329) observes that it consists of "objects that create the grounds on which other objects operate." As such, infrastructures enable imaginaries and materialities "at scales greater than their elements" ([15] p.174).

Today, a growing body of work in 'infrastructure studies', together with research in political science, human geography, anthropology and science and technology studies, attests to the way energy infrastructures introduce rationalities of organisation and control, by connecting, dividing and territorialising, and serving as 'gathering points' for socio-political action at a range of geographical scales [16–21]. Infrastructures are, in Galeano's terms, the *open and closed veins of territory*: through these "architectures for circulation" flow matter, power and capital in ways that enable and transform the experience of everyday life [14]. Frequently an object of desire for national development and societal progress, infrastructures of energy extraction, transmission and consumption are often understood in a particular modernist/eco-modernist fashion: infrastructures represent "the possibility to be modern, of having a future, or the foreclosing of that possibility and a resulting experience of abjection" ([14], p.333). Infrastructures also hold the possibility for being sustainable, counter-hegemonic or sovereign and, consequently, they are often closely tied to questions of identity and nationhood [22]. In this context, Cherp et al. [23] show how the same element of infrastructure can be viewed simultaneously from different disciplinary angles (e.g. economic, physical, socio-technical and political) by conceptualizing national energy transitions as a co-evolution of three types of systems: energy flows and markets, energy technologies, and energy-related policies. It is clear, then, that the capacity of energy infrastructures to sustain political and economic power—what we refer to here in shorthand as the 'politics of energy infrastructure'—might be understood in several different ways. Hence, in this section, we review the literature to outline five different understandings of the political and economic work which energy infrastructures enable.[4] Our objective is not to offer a comprehensive review of all the available literature but, instead, to identify key areas of difference in how the political capacity of energy infrastructures are conceptualised. This then allows us, in the following section, to identify the specific contributions of the Special Issue to the existing literature given its focus on the resurgence of energy as a national concern.

### 2.1. Power play: energy infrastructure and classical geopolitics

There is a large and extensive literature in political science and international relations on the politics and geopolitics of energy infrastructures [24,25]. This work examines the "the geopolitical forces that shape the course of energy transmission projects" in a context of interstate competition and collaboration ([26] p. vii). It views energy resource and infrastructure questions through the traditional lenses of geopolitics: the balance of power among nations, and strategic advantage. From this perspective, energy infrastructures are "integral to geopolitics (because) they fuel the material notion of power (e.g., economic and military) by their strategic relevance to political systems operating on the basis of resource competition" ([112] p.100). Common foci in this work are transboundary transmission systems and cross-border investments in energy infrastructure, such as power stations, gas import terminals, and gas storage. Fischhendler et al. ([27] p.533), for example, examine the geopolitics of regional electricity grids in the eastern Mediterranean, and find that electricity transmission networks have been both "a platform for deeper international cooperation and…a stick against neighbouring states".

The interest of conventional geopolitics in energy infrastructure underpins recent work on cross-border security of energy supplies [28,29]. This perspective has informed the European Commission's response to growing energy imports into Europe, particularly following the interruption of Russian gas supplies to Europe during the 2006 dispute with Ukraine, and again in 2009 [30,31]. However, it also extends beyond a narrow concern with the strategies of importing states to consider the range of geopolitical forces shaping energy infrastructure, including the efforts of some states to position themselves as

[4] Our use of the word 'locating' in the subheading to this section reflects our sense that it is important to differentiate current work by reference to the way it understands the social power of infrastructure and, in particular, from where it regards this power to derive.

an 'energy hub' or an 'energy transit state.' The focus here is on how geographic location can be harnessed through infrastructure to enhance regional power: work on Turkey, for example, points to the country's "inherent geography – its classic position as a crossroads between east and west, between north and south" as an opportunity to become a gas transit country for Russian gas, and gas from Central Asia and the Middle East, thereby enhancing its regional position via oil, gas and petrochemical infrastructures [32] p.39; [33–35]. Such opportunities often give way to nationalist ambitions of not simply being a 'transit country' but an 'energy hub,' with the perceived power to control flows of energy and capital. This work also recognises the potential of large infrastructures to effect broader political change – e.g. 'pipelines for peace' [36], 'liquid/water power' ([37], see also [38]) and other work on the (geo)political consequences of cross-border infrastructures [39]. Fischhendler et al. [112] p.101 note, for example, that the large-scale solar Desertec initiative in North Africa "was initially celebrated as being capable of contributing to regional economic and political stability in North Africa and the Mediterranean by creating win–win scenarios for participating nations." A defining characteristic of this work is its focus on the goals and strategies of national actors, and the 'power plays' among them around key infrastructure including opportunities for international co-operation [40].

### 2.2. Uneven development: reproducing political-economic inequalities

A second body of work, which draws from critical political economy, highlights the effects of energy infrastructure on socio-economic outcomes. It focuses on the (re)production of socio-economic inequalities through energy infrastructures at a range of scales, from the urban dynamics of electrification in the global South to regional and global economies. This work examines how energy infrastructures "distribute social costs and benefits […] in a profoundly unequal way" ([46] p. 157). It shows how the 'modern infrastructural ideal' of universal access guided by an ethic of public service has been highly specific, historically and geographically, in relation to energy provision [20]. Tonkiss ([41] p.385) points out how infrastructures have a "connective and collective potential, which is only patchily realized in actual systems of provision and regulation." Indeed, the "inherent contradiction and slippage between (infrastructure's) planning and enactment" and the way it frequently "fails to function to its full capacity" are recurring themes in work on the political economy of energy infrastructure ([42] p.165). Spatial patterns of under-provision around transmission and distribution systems have been a core focus of work on energy access [43], and on the political economy of infrastructural failure and resilience. In this context, Sovacool and Cooper [44], for instance, specifically examine why energy megaprojects—initiated to improve energy security—ultimately fail to deliver their promised benefits. In a similar vein, a body of work on splintered urbanism [45] and the existence of multiple, parallel infrastructures, makes sense of the variegated and partial implementation of the connective ideal, and for understanding how technical, administrative and commercial interventions in electricity infrastructure create political and economic differentiation at the urban scale [20]. Works like these highlight how infrastructures such as electricity transmission and distribution grids not only ferry electrons, but their geographical reach, terms of access and forms of ownership reflect prevailing distributions of economic and political power. A key finding is that "infrastructures involve diverse economies of investment, ownership, exchange and use […] (and) produce and reproduce distributional inequalities in material, and deeply spatial, ways" ([41] p. 384).

There is rich literature on the historical political economy of energy infrastructure in the US and Europe, which highlights how infrastructure has always been a terrain of engagement, deliberation and politicisation among businesses, the state and citizens. In commenting on the development of energy transport infrastructures in the US mid-Atlantic, Jones ([46] p. 160), for example, notes that "canals, pipelines and wires were not simply mechanisms for moving power: they were weapons used in highly competitive industries to squelch competitors and increase the financial power of particular parties." Similarly, Jones [46] observes how access to electricity only became widespread in the US after reformers organised the crowds that electric companies had chosen to ignore. In much the same way, it was only in response to civic action and pressure that the New Deal administration in 1935 supported rural consumers who wanted to build their own transmission lines and electricity cooperatives. Seeing the success of such initiatives, utility companies then had to regulate their rates and expand service coverage to rural consumers. From an historical point of view, then, it is clear that what energy systems 'do' goes beyond storing, moving and transforming materials. Energy infrastructures, such as power lines, dams or pipelines create connections between distant communities or among businesses and bureaucrats that would not automatically work together [47].

### 2.3. Dreamscapes and poetics: sociotechnical imaginaries and critical geopolitics

A third body of work draws inspiration from critical geopolitics and science and technology studies and acknowledges the political ambiguity of energy infrastructures. It denaturalises spatial relationships that classic geopolitics sees as fixed and inherent, by exploring how space is socially-constructed through energy infrastructure. Specifically, it asks how energy resources and infrastructures become scaled as national concerns, and the various imaginaries – of space, self and other – that converge upon, and are given life through, energy infrastructures. Fischhendler and Nathan ([48] p. 160), for example, assess the way in which the development of offshore gas infrastructure in Israel has been framed by reference to national energy security, and how this legitimizes "the taking of extreme legislative measures which are above normal politics." They conclude, contra classical geopolitics, that energy security is not a given but, instead, "an evolving social concept shaped by the strategizing tactics of actors who make use of linguistic and rhetoric constructs to express societal vulnerabilities." Firat [49] provides a similar narrative on Turkey's ambitions to make its people and territory politically relevant to the EU in a time of authoritarian populism. Networked energy-transport infrastructures around gas and electricity, for example, enable its political elite to materialize 'political dreamscapes' of becoming an 'east-west energy corridor'.

A similar perspective, albeit one that originates in science and technology studies rather than critical geopolitics, is found in the work of Jasanoff and Kim [50,51] on socio-technical imaginaries. They show how national science and technology projects "encode and reinforce particular conceptions of what a nation stands for" ([51] p. 120). They coin the term 'socio-technical imaginaries' to refer to the "collectively imagined forms of social life and social order reflected in the design and fulfilment of nation-specific scientific and/or technological projects" ([51] p. 121). In their comparison of nuclear power in the United States and South Korea, they show how imaginaries "articulate feasible futures […] and activ(ate) collective consciousness…(helping) create the political will or public resolve to attain them" ([51] p. 123). This work makes clear how energy infrastructures are frequently a fertile site of national imagination, given the way they compose and materialise the territory of the state; the sovereignty of (most) national governments over many energy resources (waters, minerals); the frequent mobilisation of domestic natural resources (water, soils, forests, hydrocarbons) in nation-building projects [52]; and the way in which, for many resource-exporting countries, energy resources and infrastructure are a "fulcrum on which turn the country's relations with the global economy" ([53] p. 694). In their work on hydropower resources in Turkey and Israel, for example, Harris and Alatout ([54] p. 148) show how "the hydropolitical construction of scale (is) central to state and nation building, and their territorial consolidation."

Larkin's [14] comments on the "poetics" of infrastructure are useful,

here, as they draw attention to how infrastructures exist "as forms separate from their purely technical functioning […] they emerge out of and store within them forms of desire and fantasy and can take on fetish-like aspects that sometimes can be wholly autonomous from their technical function." Focusing on the poetics of infrastructure, he argues, "allows us to understand how the political can be constituted through different means" ([14] p. 329) – i.e. the capacity to produce symbolic meanings and "establish sets of effects" ([14] p. 336). While it has become commonplace (following Star [13]) to comment on the invisibility of infrastructure, Larkin suggests the politics of infrastructure frequently involve the visible circulation of infrastructures "as signs of themselves" in ways that have symbolic effects. Energy infrastructures are frequently fertile sites through which to produce these symbolic effects. They have particular potency for constructing or reproducing national consciousness because they are hybrid phenomena that combine human labour with territorially-embedded raw materials. This said, energy infrastructures are also paradoxical insofar as they are "rigid and fluid [and] meant to last" yet also "doomed to be outmoded, ruined, and exceeded". Therefore, bringing energy infrastructures to life also marks "the limit of our collective imaginary" ([55] p. 13). The production of energy landscapes, such as mines, dams, power stations and the development of transmission grids for electricity and natural gas, readily feeds collective imaginaries of national modernisation [56–59]. Those who labour in these energy landscapes, and whose work therefore fuses nature and nation, frequently acquire symbolic and material power [60].

### 2.4. Inscribed social values: the technopolitics of energy infrastructure

A fourth perspective on the politics of infrastructure recognises how social values and policy choices are inscribed within the design and operation of ostensibly technical systems [61,13]. In effect, it places politics further 'upstream' than does either conventional geopolitics or political economy, by showing how political considerations get built into infrastructural systems before they leave the drawing board. In her work on nuclear power infrastructures, for example, Hecht [5,85] coins the term 'technopolitics' to highlight "the strategic practice of designing or using technology to enact political goals" ([85], p.3). In research on apartheid-era South Africa, for example, Edwards and Hecht [62] show how "technological projects figured in the practices, symbolisms, and political narratives marshalled by apartheid apologists and anti-apartheid activists." The term 'technopolitics' in this context conveys how "the entanglement of technology with narratives of national and social identity had concrete political dimensions and material outcomes." A consistent line of enquiry in Hecht's research is to show how technological and political orders are co-constituted, and how one of the paradoxical outcomes of this process is the appearance of technological infrastructures and politics as two separate domains ([5,85]).

An important emphasis in this work is on the material qualities of technopolitical systems, and how these "shape the texture and the effects of their power" ([85] p. 3). There is an acknowledgement that these influences often exceed deliberate intent, as "material things can be more flexible – and more unpredictable – than their builders realize […] the way they reshape landscapes, for example, or their capacity to give or take life – sometimes offers other actors an unforeseen purchase on power by providing unexpected means for them to act." Research has built on this insight to consider, following Foucault, how demand-side infrastructures can be integral to liberal rationalities of governance because of the way they induce particular forms of subjectivity (thrift, responsibility, independence) and general conduct among a population [14]. For example, this line of enquiry has been picked up by contemporary work on smart meters and carbon budgeting in the context of the domestic home. Rutland and Aylett [63], for example, reflect on the centrality of responsible, carbon-calculating consumers to Portland, Oregon's Carbon Dioxide Reduction Strategy; and Paterson and Stripple ([64] p. 347) point to the proliferation of individualised calculative infrastructures around energy use and carbon emissions – smart meters, carbon footprints, personal carbon accounts – and how these rely on "peer pressure, comparison, communication […] validation, (and) innovation" to achieve the "conduct of carbon conduct." Creating alternative pathways is a central challenge in rethinking technologies, infrastructures, institutions and politics of energy today [19]. However, responses to periods of global crisis like the current authoritarian populist turn can also enable a new politics of transformation [65].

### 2.5. Materials enrolling publics: energy infrastructure as a 'gathering force'

A fifth perspective recognises the disruptive and generative capacity of energy infrastructure, and how it is "a gathering force and political intermediary of considerable significance" ([66] p. 137). The emphasis in this work is on the "unpredictable power effects of technical assemblages […] the unintentional effects of the (re)distribution of agency that they enacted' ([85] p. 3). Mitchell [67], for example, examined the different political possibilities afforded by coal and oil infrastructures in the twentieth century, to explore how energy networks and their constituent components distribute political agency and nurture particular identities (*vis-à-vis* the state, for example). This work builds on a view of infrastructure as co-ordinating and structuring social life, and starts from the simple proposition that infrastructures "are implicated in the human experience of the city and in shaping social identities" ([66] p. 139). For example, Angelo and Hentschel ([68], p. 307) observe that "the many interactions taking place simultaneously throughout large-scale systems accumulate as broader and relatively stable patterns of social practices, understandings and relationships. Infrastructural systems "establish political space" by enabling "collectivity through connectivity" ([69] p. 172) and produce multiple spatialities [70] and polities. Recent work on energy democracy takes this a step further by calling for the commoning of energy infrastructure "in, against and beyond the state," leveraging struggles over energy infrastructure as strategies for broader political goals ([71,72]). This also includes attention to achieving a socially-just form of transition out of fossil fuel lock-in, for frontline communities in the hydrocarbon commodity chain [73].

The political potential of infrastructures to create new collectivities and political arrangements extends beyond the work of their material connections (the focus of Opitz and Tellmann [69], for example) to the way infrastructures actively enrol different publics. Barry [74]'s work on the Baku-Tbilisi-Ceyhan pipeline shows how physical materials are constitutive of political relations in ways that have yet to be fully acknowledged (see also [75]). Barry insists on the liveliness of materials and their capacity to act in unexpected ways, showing for example how technical concerns about cracks mobilize across space in unexpected ways through their informational content, creating new publics via a topology of heterogeneous and otherwise disconnected actors. In this regard, Barry's work shares a similar impetus to Jane Bennett and her work on electricity grids and blackouts. However, Barry and Bennett arrive at quite different understandings of how materials become political [76]. For Bennett [77], political capacity stems from what she terms 'thing power', the 'quivering effervescence' (p. 55) of all things, which lends matter a vitality and productive power beyond human intention. For Barry ([74], p. 16), however, the excess of materials arises from their "encasing […] in an array of figures, traces and samples" as they travel and proliferate, generate witnesses and publics. In this work, then, one finds a commitment to a "certain form of empiricism" ([74] p. 183) that does not take as self-evident the political character of any particular actor, institution or material. This position questions why and how particular objects and events become discernible and acquire transnational political significance. Such a perspective radically challenges conventional accounts of the geopolitics or political economy of energy, which centre on the assumed significance of states, firms and/or social movements and their interactions with geophysical resources.

## 3. Key themes of the Special issue

Four main themes emerge from the contributions to this Special Issue. These imperfectly echo the five different bodies of knowledge identified in Section 2 and illustrate some of the different types of political and economic work that energy infrastructures accomplish in the name of the 'nation'. The first relates to *the strategic role that energy infrastructure plays along the lines of classical geopolitics and the political economy of development*. There are cases where—depending on the context and circumstances—energy infrastructure is at the centre of reasserting the role of the state or market in national development and realising its capacity in shaping economic and social life. The second theme concerns the more ambiguous power of energy infrastructures as *national energy imaginaries*, where energy resources and infrastructures are bound up with socially-shared ideas about the nation's place in the world and its modernising passage from past to future. Third, energy infrastructure decisions frequently raise questions and concerns about theirtechnopolitical character – i.e. *questions about how and through whose knowledge we come to know energy infrastructures and energy transition*. The fourth theme in the energy infrastructure and political power nexus arises on the basis of *cross-scale connections of 'national' infrastructures and resulting scalar tensions*.

In exploring these four themes, articles in this Special Issue intersect with conceptual and theoretical work that reflects a breadth of social science research. By and large, they focus on infrastructures deemed nationally significant and associated with supplying energy from oil, gas, nuclear, coal and renewables such as solar, wind and water. There are also contributions that focus on the climate-related aspects of energy systems and the low carbon transition, thereby extending the meaning of energy infrastructure. Geographically, the research papers cover a broad expanse of locations across OECD and non-OECD countries, including jurisdictions where issues of energy and the political economy of national development are particularly at stake (e.g. China, Brazil, Ecuador, Kenya, Tanzania), energy supply is closely bound with notions of nationhood (e.g. Poland, Turkey, Kosovo) or energy transitions are disputed (e.g. Germany, Denmark, the USA). In the following, we further characterise how 'energy infrastructure' and the 'national' merge around these four theme in a manner consistent with our literature review. We also introduce the individual papers, organised under the four themes, and highlight their contributions.

### 3.1. Energy infrastructure: market frontier or state-led national development?

Research on energy infrastructure with a political economy focus necessarily engages with questions of economic development, where a key axis of debate is around state-led versus market-led approaches to investment and national development. Through which economic and political logics do energy infrastructures materialise? Is it with an entrepreneurial spirit and through the profit-generation motives of corporate actors, as part of market liberalisation? Or is it linked, in some sense, to the notion of a public or common good, and related to the developmentalist state ideal? What are the consequences of these different organisational models on people's lives and on their social and cultural environments? What social and spatial distributions of social power do energy infrastructures sustain, and how do they enable different forms of economic organisation – e.g. markets or vertically-integrated natural monopolies – to take hold? The political-economic contexts in which issues of national development are reasserted in debates on energy infrastructure are diverse, and significant elements of infrastructure projects are necessarily site-specific. As a consequence, grounded contextual analysis is required to decipher the different logics and rationalities that drive infrastructure investment decisions and their implications. Contributions to this Special Issue illustrate the value of such grounded analysis for understanding how political-economic logics articulate with contextual factors. They demonstrate how alternative investment logics and development models are at the heart of attempts to harness energy technologies and infrastructures in ways that reproduce political power and further the interests of their enablers and certain other groups in society.

*Purcell and Martinez-Esguerra* [82] provide a structural account of the circulation of natural resource rents into large-scale energy infrastructures in 'post-neoliberal' Ecuador. Although the country's oil reserves have supported social spending and debt in Ecuador since the 1970s, the current Ecuadorian government is seeking to transform the country's 'energy matrix' away from its reliance on oil and drive national industrial development based on cheap electrical energy. Based on in-country fieldwork, and drawing on neo-Marxian value theory, the authors show how Ecuador's current model of state-led development leverages natural resource rents and foreign (Chinese) debt to install massive hydropower facilities in the country, such as the 1500 MW Coca Codo Sinclair project. Their account highlights the limits of this state-led development policy and shows how, by channeling an abundance of cheap hydroelectric power towards mining, Ecuador is deepening rather than overcoming the country's natural resource dependence. *Eren* [86] examines the consequences of liberalised electricity markets for the management of river systems in northeastern Turkey. Her account situates Turkey's contemporary hydropower boom in the context of the state's adoption of neoliberal water and energy policies. Using the case of the İkizdere River Basin on the Black Sea coast, she shows in detail how liberalised energy markets encourage operators of Run-of-River hydroelectricity plants to build water storage and channel structures that minimize variability in the river's flow. Her paper foregrounds the combined natural and engineered 'infrastructures' of the water-energy nexus, demonstrating how the commercial logic of the electricity market now conditions in-stream flows in ways that are significant for a range of river users.

The role of the state and private capital in energy infrastructure often comes to the fore around the emergence of new energy landscapes. However, fixed capital and equipment must also be brought out of service and actively decommissioned, a process that raises similar questions about risk, responsibility and infrastructure as a market frontier. *McCauley* [87] explores how decommissioning is understood in the context of two complex energy infrastructural systems that have developed over many years: offshore oil in Scotland, in the context of the decline of North Sea oil production; and nuclear power in Germany, following the federal government's decision to phase out nuclear in 2011. In both cases, the scale of decommissioning activity and the timeframe over which it unfolds are very extensive, yet policy makers and business actors frame the challenge of decommissioning quite differently. McCauley shows how state and private actors in Scotland understand decommissioning as an infrastructural investment opportunity, in a way that contrasts with the perspective of policy makers in Germany with regard to the country's nuclear phase out.

*Hoffman* [88] offers a critique of how energy resources and infrastructures are positioned in the development literature, in terms of their materiality and the tendency to offer deterministic answers to the big questions of development/underdevelopment. Hoffman argues that the tendency to see all social relations that arise from energy-related interactions in the Middle East as being determined by the physical extraction and transfer of energy resources is problematic. He offers an alternative perspective that privileges the social over the material, by looking at the socio-historic dynamics of energy relations in autonomous regions in northern Syria. By redefining energy as a political category, that is as a field of social struggle and changeinstead of a limiting biophysical structure, Hoffman shows how social life develops in relation to energy resources and infrastructures but is not singularly determined by it.

The politics of hydrocarbon-fuelled development are at the centre of the article by *Andrews and Nwapi* [89]. In their analysis of variants of petro-developmentalism in Ghana, Mozambique and Uganda, the authors shed light on the intersection of political power, institutions and

national ambitions for development. Their critical discussion on emerging developmentalisms in the African context and their differences from East Asian experiences offers an explanation for how the peculiarities of developmental state are interwoven with hydrocarbon infrastructure in these three countries. Their findings demonstrate the relevance of development-oriented political leadership, effective bureaucracy, governance models and conflict management between energy actors. Turning to electricity infrastructures, *Sergi et al.*[90] focus on the trajectories of off-grid investments and the role of financial support by international development agencies in Kenya and Tanzania. Mobilizing a multi-level perspective framework, Sergi et al. observe that different institutional regimes in these countries result in different development pathways for off-grid energy. By using data on international development aid flows, the authors conclude that foreign aid donors, state bureaucracies and market players often favour on-grid infrastructures despite lip service to off-grid solar investments. Along similar methodological lines, *Cai and Aoyama* [91] examine the impact of China's fragmented bureaucracy on wind power curtailment. Suggesting that China's top-down, technocratic approach to clean energy infrastructure is not necessarily more effective in clean energy transitions, Cai and Aoyama reflect on misalignments in the flow of power across state institutions and territories. The authors conclude with a word of caution on the use and praise of incentives in a highly centralized, non-participatory policy landscape.

*Pallesen and Jacobsen* [92] explore the case of EcoGrid 2.0 on the Danish island of Bornholm, as an example of a 'marketized' solution to infrastructural challenges raised by growing installed wind power capacity. The authors show how consumers are rendered somewhat controllable and predictable actors in the energy system when demand-side flexibility is commodified. However, this is only enabled, the authors argue, by radical changes that meld private households into existing infrastructures, and by adding a digital layer capable of tracking consumer behaviour. The consequent 'customer-citizen' that emerges becomes, within Denmark's official eco-branding as the *State of Green*, a key protagonist in crafting market-solutions to infrastructural problems. This section closes with a short Perspectives piece by *Tsai* [93] which considers the relationship of national development, energy governance and energy infrastructure. Focusing on the Gulf Cooperation Council (GCC) region, Tsai reports an observed paradigm change in the rentier social contract that GCC states are undertaking in the face of low oil prices, intensifying regional conflicts, increasing domestic energy consumption and inefficient power generation, and shows how energy subsidies—a key instrument for rent transfer—are gradually being replaced by premiums associated with state-provided jobs. According to Tsai, this paradigm change, facilitated by the extension of state control from the oil to the non-oil energy sector, tends to reinforce the authority of the ruling elite and has implications for the near-term institutional setting of energy infrastructure development in the GCC.

### 3.2. National energy imaginaries: securing energy for the nation

A second set of articles in the Special Issue explore cases where the contemporary reassertion of the national scale, and the role of the national 'state' in particular, coincides with the activation of socio-technical imaginaries that revolve around the strategic role energy infrastructure can play in a nation's future. Contributions in this section show how investments in energy infrastructures are increasingly framed as vital national projects. The national imaginaries guiding energy infrastructure politics are diverse: sometimes they arise in energy resource states, where infrastructures are dedicated to energy extraction and export; in others, it is concerns about energy security and imports, transition to a new economic order, or decarbonization and sustainable energy. Papers in this section reveal that, whatever the motivation, the branding and/or marketing of domestic energy infrastructure strategies by national states serves to materialise abstract power and continuously reproduce it.

*Rickards and Opperman* [94] examine the role of electricity infrastructure in managing national climate anxieties in Australia. The authors highlight the role of electricity and air conditioning in subduing the hot, recalcitrant regions of tropical northern Australia and bringing them into the body of the nation. They reflect on the contemporary role of electricity in securing against regional climate change and how, in turn, securing electrical infrastructure depends on a particular combination of bodies (e.g. line workers) and geopolitical strategies. *Bennertz and Rip* [95] turn their attention to the sociotechnical evolution of automotive-energy infrastructures in Brazil in the twentieth and early twenty-first centuries. They explain how ethanol—positioned as a national fuel—has stayed embedded in the process of national development throughout the years, as a modernizing force for an earlier export-based economy. Their paper sheds light on the linkages and residues around ethanol and automobility in Brazil, and how they enable and constrain further developments. The authors argue that the Brazilian automotive-energy infrastructure is not the result of an explicit design and implementation process, but an accumulation of minor and major entanglements that, over time, have solidified in path-dependent 'knots' which now shape further developments.

*Arifi and Späth's* [96] article focuses on the multiple uses of energy security in legitimizing and countering a coal-fired power plant project in the young republic of Kosovo. Embarking on an analysis of counter-conduct and resistance, the authors suggest that securitization of energy as the backbone of national economic development in Kovoso both challenges and reinforces the status quo. Their findings point to an inherent problem among social movements, which embrace the very rationalities and practices of the governing regime they seek to challenge. Their analysis ties well with the contribution of *Tarasova* [97], who delves into the neoliberal market rationality of nuclear energy development in Russia and Poland. Tarasova shows how particular energy infrastructures are legitimized and rendered as inevitable, rational alternatives with discourses of economic growth, innovation and energy security. Nonetheless, Russia and Poland present distinctive cases as legitimization takes the shape of different market rationalities adjusted to the broader national identities of the two countries.

*Kuchler and Bridge* [98] explore how coal has shaped national narratives of resource abundance and energy security in Poland. Their article focuses on the socio-technical imaginaries surrounding coal extraction and coal-fired power generation, and their historically grounded perspective highlights the material ambiguities of coal in this context. Bridging national imaginaries and infrastructural materialities, their findings point to the revival of a 'black gold' imaginary in Poland, albeit in a new shape with emphasis on 'clean coal technologies'. Following a similar historicization of national energy imaginaries and neoliberal transformation, *Erensü's* [99] contribution traces three decades of Turkish energy policies culminating in *Milli Enerji*, a rebranding of business-as-usual energy policy only armed with the coercive powers of the state. Building on ethnographic anecdotes and official document analysis, Erensü provides insights on the authoritarian turn and the 'happy marriage' of neoliberalism and developmentalism in Turkey around energy infrastructures. When merged with national imaginaries of political/diplomatic power and economic potency, energy infrastructures often fan the flames of populist rhetoric, as seen around the world from the Keystone XL pipeline in North America [78] to the Ilısu Dam in Southeast Anatolia [79]. Finally, *Sklarew* [100] examines the Japanese nuclear infrastructure before and after Fukushima by focusing on the role of vested interests in driving continuity or change. She demonstrates how a convergence of decades-long infrastructure prioritization and the political power of private interests led to a lock-in of nuclear power. Sklarew argues that incumbent interests and institutional alignments at the national scale determine whether Japan's energy infrastructure policy will undergo a lasting change and allow transformation within an incumbent system after a shock like Fukushima.

### 3.3. Experiencing infrastructure on the frontline: alternative and competing knowledges

The third group of articles in the Special Issue looks at energy infrastructures not as feats of engineering and/or the result of economic action but as embodying specific forms of knowledge. They ask, in effect, whose knowledge informs decisions related to energy resources and infrastructures? Such questions, about who decides and whose perspective gets to count, are particularly important at a time when popular authoritarian and post-truth regimes are on the rise. Two important issues here are (i) what do we do with alternative systems of knowing and valuing that are not readily accommodated within energy infrastructure decisions, where there is a technocratic/modernist tendency to legitimise certain strands of scientific knowledge at the expense of others?; and (ii) what happens when the 'national' scale (while, potentially, a space for leveraging claims) becomes an oppressive force and a zone of exclusion against claims for the recognition of rights and participation? Papers in this section suggest that the key to addressing these questions lies in connecting the broader structures at play with deeper analysis of the politics of knowledge, and thinking about global production networks, rents and finance in conjunction with issues of participation and justice, including spatial and intergenerational ones.

*Plumridge Bedi*'s [101] paper adopts a bottom-up perspective on energy infrastructure to highlight how many of those opposed to coal-fired power generation (and coal mining) in Bangladesh mobilize claims about energy rights. In a country where over 40% of the population lack access to electricity, her account centers on the proposed Rampal project, a major new power station development in collaboration with Indian capital, situated less than 20 km from the ecologically-sensitive Sundarbans region in the south of the country. She shows how the language of rights in this context is a rejection of inherited energy systems and an effort to wrest back control over energy decisions. It reflects an awareness that foreign states, corporations and financial institutions have historically shaped decisions over energy infrastructure in Bangladesh. Her paper shows, in other words, that how energy infrastructures are understood – as, for example, securing new energy access and promoting development versus imposing costs on vulnerable groups and contributing to climate change – depends on the historically and geographically situated experience of affected communities.

*Finley-Brook et al.* [102] also reflect on the 'frontline experience' of expanding energy infrastructures. Their account centers on the build-up of the infrastructures for extracting, storing, transporting and transforming natural gas in the mid-Atlantic region of the United States, in the wake of the hydraulic fracturing boom. The authors reflect on their experience living and working at the center of this new energy assemblage, deploying what they term a 'participatory action research' perspective. They mobilise the term 'infrastructuring' (cf. [80]) to refer to this contested process of expanding infrastructure and to highlight the 'frictions' [81] that arise when communities encounter energy infrastructure. Their grounded perspective offers a framework for critical energy justice that is able to think across a wide range of components. Likewise, *Ablo and Asamoah* [103] consider the localised implications of new gas infrastructures, focusing on Ghana. Their account centres on the experience of farmers affected by the recent development of the Atuabo gas processing project, where gas arriving onshore from the country's large offshore gas reserves is treated. They emphasise the situated experience of energy infrastructure and how affected farmers were able (or unable) to participate in determining compensation payments. They found that farmers were often not involved in the compensation process beyond the identification and measurement of their farms. With limited participation in the acquisition and compensation process, farmers felt deprived of what they were entitled to and viewed the compensation as inadequate in the face of their lost livelihoods and generational inheritance

*Siciliano et al.* [104] examine how local knowledge and development priorities can more effectively be included within centralized decision-making processes around large dams. Their article highlights how assessments of priorities and needs around dam infrastructures frequently diverge across different scales. To remedy this and capture the full environmental and social costs of dam schemes, the authors adopt an energy justice framework. They apply their framework to analyse distributional, procedural, restorative justice, and power relations associated with four major dam schemes in Africa and Asia, and show how it can inform energy decisions on infrastructure development based on energy justice principles and social impact evaluation. *Prinz and Pegels* [105] bring class back into the spotlight of energy transition research, in the context of the much-lauded German *Energiewende*. Exploring the forces of continuity and change, Prinz and Pegels reflect on the role of collective mobilization in the future of the German energy transition and how it is likely to be shaped by internal power struggles within the labour movement. Energy infrastructures are constituted not only by political-economic bargaining, institutional reconfiguration and the social contestation of frontline communities, but also by the competing knowledges and value pluralities of different social groups.

*Knuth* [106] engages important questions of knowledge in the rather different context of breakthrough technologies and clean-tech. Her article focuses on a specific instantiation of the cleantech debate in the US, provoked in part by Bill Gates' formation of a so-called Breakthrough Energy Coalition in the lead up to the 2015 Paris climate talks. Knuth shows how competing knowledges and visions are in play in responding to questions such as what breakthrough knowledge means for the long-term development of a socio-technical system such as energy infrastructure. One group of entrepreneurs and venture capitalists argue that 'breakthrough' clean energy technologies are needed for an energy transition that will push US economic power into the twenty-first century. Meanwhile, a competing set prioritises deploying existing technologies and infrastructures at scale, arguing that new kinds of innovation can accomplish this task, and in the process defend embattled US hegemony. Notably, these centre on financial innovation and new articulations between finance and high tech. In her analysis, Knuth sheds light on how seemingly novel development visions for disruptive cleantech and clean energy transition have, in fact been shaped—and constrained in key ways—by established economic strategies and imaginaries. Her article considers the implications of her findings for the politics of energy transition and green economy at large.

### 3.4. Scalar tensions around 'national' infrastructures

The collection of papers in the final part of the Special Issue offer a critical look at the relationship between energy infrastructural development at the national level and other sites—at the global, regional or local scales—and the effects and outcomes of energy investment decisions in terms of connections, activities or conflict. These multi-scalar tensions take a number of forms, from the contingent and often precarious coupling of international capital flows for infrastructure with national and regional development objectives, to problems related to international agreements: because signatories are nation-states, there can be sub-national (i.e. regional) resentment due to being excluded from negotiations around economic rents, jobs, socio-environmental impacts and associated risk assessments and compensation. Overall, tensions between national sovereignty over the energy sector and sub-national and community perspectives are at the heart of these discussions.

*Kennedy* [107] examines the emerging geographies of renewable energy generation resulting from the rapid influx of foreign investment in Indonesia's solar photovoltaic (PV) sector. His paper shows that while foreign investment may prove successful in increasing the country's solar PV capacity at the national level, the risk-return logic of finance associated with large-scale, capital- and land-intensive, power generation facilities produces contradictory outcomes for Indonesia's

energy transition: specifically, it constrains opportunities for local ownership and control over the energy system. Viewed through the lens of Indonesia's development objectives around energy transition, Kennedy argues that there is not only a flow of economic benefits out of the country and limited improvement in energy access overall, but a missed opportunity to maximise the socially and politically transformative potential of energy transition.

*Geall et al.*[108] describe the constraints of a top-down, state-sponsored push for new energy infrastructure in China that lacks sufficient incentive mechanisms for non-state actors. Through a pilot case study on solar energy development in a remote and largely pastoral region of Qinghai province on the Tibetan plateau, Geall et al. show the limits of a solar energy for a poverty alleviation programme (SEPAP). Specifically, they demonstrate how it lacks independent oversight of the command and control system, and there are contested local perspectives on the building of ostensibly low carbon infrastructure for electricity generation. Their article suggests that while the solar initiative was framed as capitalising on the synergistic goals of energy supply and poverty-alleviation, actual governance authority resided with energy regulators in Beijing. Regulators were experienced in driving industrial policies to expand supply-side capacities, but much less able to address complexities at the village and county level that ultimately determine policy outcomes for poor households. Multi-scalar tensions are also at the centre of *de Bercegol and Monstadt*'s [109] article, which explores the multiscalar political economy of electrification in Kibera, one of the biggest informal settlements in Nairobi, Kenya. The authors demonstrate how a World Bank-funded Kenya Slum Electrification Program extended a socio-managerial approach to energy access, producing new consumer-citizens in the process. Built on an in-depth case study, the article contributes to the debates on splintered and incremental infrastructures by emphasizing socio-economic access beyond physical connectivity.

*Schritt* [110] examines how political efforts in Niger to wrest national value from the development of oil resources have come to centre on local content and participation requirements. Niger entered the ranks of oil producers in 2011 with the establishment of crude oil production and domestic refining via a joint-venture arrangement with China National Petroleum Corporation. Schritt uses ethnographic techniques to explore the material politics of Niger's new 'oil zone' and places the infrastructures and standardizing processes associated with oil at the heart of the analysis. His account highlights the public controversies that immediately grew up around the infrastructures for extracting, processing and exporting oil, revealing how different aspects of oil infrastructure became meaningful to various publics in Niger. The paper focuses on three controversies in particular – those associated with exporting oil and controlling its flow, measuring the content and value of oil exports, and knowledge transfer and standards associated with the Chinese oil sector.

*Sareen and Kale* [111] show how regional particularities and path dependence have shaped the emergence of solar energy infrastructures in Rajasthan and Gujarat. These two western Indian states both have high irradiation potential but offer contrasting renewable energy trajectories: Gujarat moved early and fast into solar, but Rajasthan turned to solar only after the development of a national solar policy in 2011. The authors argue that a form of 'energy federalism' characterises moves towards decarbonisation in India: that is, energy transition is constituted through multiple spatial scales involving global policy, multinational actors, the Indian federal government, and state-level actors and agencies, and occurs against a backdrop of incomplete electrification and partial liberalisation. The authors bring their analysis of the multi-scalar political economy shaping renewable energy in India into conversation with normative arguments about development and energy equity and justice. They do this by exploring how solar infrastructure delivers on goals of equity, affordability and inclusive participation.

## 4. Reflections and conclusions

This Special Issue highlights a contemporary 'infrastructural moment' in relation to the recent and prospective build-up of energy systems, from large megaprojects associated with energy capture, conversion, storage and transmission to the multiple replications of manifold and frequently mundane infrastructures for energy distribution and consumption. An important feature of this period—we have suggested—is the re-centring of national development and the fate of the nation within debates over energy futures. We have assembled a collection of articles in this Special Issue that speak, in different ways, to the complex intersections between energy infrastructure and the (re) production of political and economic power through energy projects deemed nationally significant. We acknowledge there are some surprising thematic silences in this collection − on the political ecologies of pipeline conflicts in North America, EU infrastructure policy and the 'Third Package' of energy liberalisation reforms, or the transformation of nationally-strategic infrastructures (utilities, power generation) into global financial assets, for example. To a large extent the thematic range of the Special Issue is the result of assembling it through a global call followed by a process of peer review, rather than commissioning pieces on particular themes (as would, for example, be the case for an edited book). We recognise these limits, and the way different thematic contributions would likely have introduced alternative conceptual repertoires to the collection. Nonetheless, papers in this Special Issue confirm why it is important for social science research on energy to better understand claims about the national significance or necessity of energy infrastructure and their intersection with political power, particularly at a time of increasingly authoritarian populism globally. To this end, contributions to this Special Issue share three things in common: first, a recognition that energy infrastructures cannot be reduced to a mere collection of technological or material objects, and that more than the storage, transmission or conversion of energy is at stake in energy infrastructure; second, a commitment to understanding how infrastructures, as objects of analysis, have the capacity to (re)produce political power and shape political outcomes and in a wide range of modalities and forms; and third, a critical perspective on discursive efforts to link energy infrastructure with the fate of the nation that challenges universalising or naturalising claims about whom infrastructure serves, and seeks to understand its socio-political consequences.

There is already an extensive literature on the political economy of energy infrastructure, including a small but growing literature in 'infrastructure studies' that addresses energy systems. This broad body of work is not all of a piece, however, as recent social science research on energy infrastructure draws on several different conceptual and theoretical traditions. One of the contributions of this Introduction to the Special Issue has been to identify five distinctive strands of enquiry within the existing literature, helping to differentiate the 'political work' of energy infrastructure. This is necessary, we think, because it is relatively easy—indeed, now quite commonplace within broadly socio-technical studies of energy systems—to make the claim that energy infrastructure is political. To deepen this perspective, we suggest, it is important to ask how political work is understood, and from where does the political capacity of energy infrastructures derive? Accordingly, we have differentiated the existing literature into five domains based on how and where they locate infrastructures' political capacity: (i) classical geopolitics which examines energy resources and infrastructures within the context of inter-state competition and collaboration; (ii) political economy and the (re)production of uneven development, focussing on socio-economic inequalities at local, regional or global scales; (iii) the ambiguous power of energy infrastructure as an especially potent sociotechnical imaginary, often associated with modernisation, renewal and the forward trajectory of national progress; (iv) the technopolitical capacity of energy systems to affect or co-constitute socio-political orders; and (v) a 'gathering force' and significant

political intermediary in its own right, shaping the rights of people and the community at large.

The papers in this Special Issue present compelling empirical evidence of how energy infrastructures are bound up with the complex multi-scalar work of national development, across a diverse set of geographical contexts. The 27 papers in the collection shed light on the different rationalities through which energy infrastructure projects are realised, in ways that overlap with the broader literature. Specifically, several papers in this Special Issue show how energy infrastructure continues to play an important role in national development agendas, whether as part of a neoliberal agenda and market expansion strategy or via the post-neoliberal turn and reassertion of the national state. They provide valuable, grounded reflections on the continuing strategic relevance of energy infrastructures in political systems and power games, and their enduring effect on socio-economic inequalities at various levels. Contributors to this Special Issue also provide meaningful commentary on energy infrastructure studies from a critical geopolitics standpoint, demonstrating how pipelines, power stations and dams can come to embody national dreams of development and other sociotechnical imaginaries associated with, for example, hopes for national economic renewal or sustainable energy transition. Several papers demonstrate the socially-constitutive power of energy systems on ways of knowing and doing, and highlight how energy infrastructures work as political intermediaries, creating new territorial formations or catalysing, by bringing together or driving apart, different social groups. Many of the papers in this Special Issue combine grounded empirical research with critical conceptualisation and, in so doing, offer insights that transcend the specific cases upon which they focus. There is, of course, more that can be done. A more comprehensive study of the political economy of energy infrastructure, we suggest, could build on the parsing of the literature begun here to address the particular forms of social power to which different energy infrastructures give rise, and the degree to which they can foster just, equitable and sustainable outcomes. An important result would be move discussion of energy transition (and energy futures more generally) away from choices over material systems or technologies, to consider the organisational forms of economy and distributions of social power that societies wish to bring about. Our hope is that this collection leads to further research on the diverse intersections of energy infrastructure with the political economy of national development.

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